RESEARCH OF RISK TAKING AND DEVIATIONS FROM RULES AT AN OPEN PIT MINE IN SERBIA

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Introduction/background: The paper pointed out the main elements of the human risk factor in coal mining. The obtained result that life satisfaction affects the observance of rules and procedures shows the complexity of human risk factor management.
Aim of the paper: The aim of this paper is to analyze the human risk factor in open pit mining, especially on compliance with safety rules and regulations.
Materials and methods: The presented survey, in the form of a questionnaire, was conducted in an open pit coal mine involving 476 mineworkers. The goals were to determine factors with the biggest influence on risk and to create a model for predicting the behavior of mining workers.
Results and conclusions: The obtained results indicate that leadership plays an important role in worker behavior. A supportive leadership style results in more responsible employee behavior and a lower probability of deviation to rules and procedures. The result also indicates that the safe behavior of workers is strongly influenced by the difficult to control factor of "life satisfaction". It has also been found that riskier work and longer work experience increases the likelihood of breaking the rules.
Research limitations/implications: The obtained results are partly influenced by national culture.
Practical implications: The obtained results indicate the need for continuous improvement in the risk management process and the rules and procedures by applying worker feedback.

Keywords: human factor, risk perception, rules, deviation from rules.

Category of the paper: Research paper.

1. Introduction

Risk management aims to provide a controlled work environment and ensure the safe functioning of the system. It is a dynamic process that works in a continual state of change and is built upon High Reliable Organizational theories and normal accidents theory (Sagan, 1993). Since the end of the 1990s, research has been conducted on building trust in the work process and increasing risk awareness, as well as providing supportive leadership, education and disaster response (Rowan, 1994). Colas (1995), for example, has pointed out that the problem of safety culture is now dealt with through a new approach, through the need of developing teamwork, as well as through the support of employee cooperation within their work units.

Clarke (2000) notes that government safety commissions often suggest and encouraged companies to improve their safety performance through creation of "positive safety culture". However, the concept of safety culture is not quite precise and clear. It consists of many social and organizational factors and needs empirical validation. She states that safety partly depends of "satisfaction with safety measures – procedures, rules and regulations" and underlines the importance of properly organized teamwork.

Among the adapted viewpoints of High Reliable Theories, he pointed out the importance of good organizational design and management, and developing a "culture of reliability" which enhances safety by supporting a uniform operator-level hazard response and error learning from accidents. According to the Normal Accident Theory, accidents are inevitable in complex systems. Partially this is due to organizational cultures following models of intense discipline, as well as faulty reporting and denial of responsibility (Moura et. al., 2017).

According to Kirin (Kirin et al., 2015a), risk management cannot be based only on the reaction to past accidents, but must be increasingly proactive. In doing so, the desired level of security in a given period must be defined and a flexible strategy based on feedback from measuring or monitoring current security levels must be implemented. People make mistakes, but people are also a very important source of security because of their flexibility and creative intellectual ability. The important part of risk management is the human factor, which is difficult to measure and predict: people may not succeed in a particular operation, they may feel tired or have health problems during their work day. It is also difficult to assess the possibilities arising from the uniqueness of human possibilities.

The human factor risk assessment includes the collection and analysis of information on human capabilities, limitations and other characteristics related to the work being observed, information about mutual interactions of people and their interactions with machines, systems and the environment in order to achieve a safe work process. People start machines, determine and adjust the organization of work processes and define and apply rules and procedures. Today's times are characterized by rapid change of technology and relatively easy change of work processes, but that does not apply to people (Kirin et al., 2015b).

Parker et al.'s (2017) researched mine worker perceptions of safe climate "between workgroups and worksites, and across age groups, experience levels and job categories". He underlined "management commitment" and "management caring" as factors of safety climate in the mines.

In addition, the individual behavior of employees can cause critical situations and thus lead to a catastrophe in high-risk workplaces. According to many researchers, unsafe behavior of workers in critical process sites in various high-risk industries is considered a direct factor contributing to workplace injuries and accidents (Xia et al., 2018).

Taking human and cultural factors into account in order to create effective risk management is one of the 11 principles of ISO 31000:2009 (The International Organization For Standardization). Human factor risk analysis also includes psychosocial risks, which are widely recognized today as the main challenge at work. Many organizations find this risk difficult to manage in practice. The OHSAS 18001 standard provides a framework for occupational health and safety risk management, including psychosocial risks (Helbo Jespersen et. al., 2016). Bell and Healey, (2006) states that the root causes of accidents are similar in major hazard industries. In most catastrophic accidents, there is a complex chain of events, which includes an organizational climate with defined policies and decision-making processes, the behavior of individuals, and technical and technological shortcomings, that in combination, results in an incident. Specific factors contributing to the occurrence of dangerous incidents are stated as: inadequate supervision of critical processes, pressure to meet set production goals, inadequate existing safety management systems, communication problems, e.g. between workers in different shifts and between staff and management, inadequate reporting systems, lack of indication of omissions that can cause danger, inadequate procedures, violation of rules and procedures, inadequate training, lack of rules and training on emergency response, lack of competence, lack of commitment attention to previous incidents and not learning from them, excessive working hours resulting in mental and physical fatigue, modifications of equipment without operator training, inadequate / insufficient maintenance, as well as maintenance errors (Bell and Healey, 2006). Herein, employee skills are usually divided into hard, which is related to job-specific, technical and technological skills, and soft – "connected with emotional intelligence" Synowiec (2020).

Chapelle points out that companies should also improve risk-reporting efficiency. One of the great challenges of risk-reporting is how to filter information and in what form to send it to improve risk management. An additional challenge in operational risk and its reporting is the analysis of qualitative data (Chapelle, 2018). Modern approaches to risk research include "interconnections among risk management, emotion, and performance metrics" (Carlsson-Wall et al., 2020).

The issue of human factor risk and rules and regulations in open pit mine is the main focus of this paper, and the intent is to develop predictive models of behavior of workers in relation to compliance with the procedures and rules. Rules and procedures are key features for a modern organization to function (Bourrier and Bieder, 2013). Policies and procedures are an important segment of risk management to ensure worker safety, process safety and environmental security of modern industrial systems. Modern management system promotes a wide scope of norms, rules and procedures in all activities. Post-incident reports are most often associated with procedures or rules: either to report about bending of rules, or to initiate improvements.

Human factor risks have been discussed and analyzed in many industries, including mining. This paper presents and discusses human factors from the perspective of risk perception, as well as perception of the existing risk and safety-related procedures in open pit mining.

2. Research methodology

The presented survey was conducted in an open pit coal mine involving 476 mine-workers, out of a total number of 2162 employees. The sample size makes up 22% of the total number of employees, and the sample represents all levels of education and all levels of the work process in accordance with their number. Given the size and construction of the sample, it is considered as representative. The survey was in the form of a questionnaire, consisting of 45 questions.

Three main goals were set: to determine factors with the biggest influence on risk, to examine workers' perceptions of rules and regulations and to create model for predicting the behavior of mining workers.

This survey also aimed to examine: (a) major human risk factors at a specific open-pit mine site (b) mine workers' opinions about policies and procedures; (c) the manner in which mine safety rules and regulations are perceived and understood; (d) the frequency of deviation from rules and regulations; (e) attitudes related to risk-taking and their interaction with rules and regulations; and (f) to anticipate the behavior of mining workers with respect to compliance with policies and procedures. The variables were constructed specifically for this research, taking care to cover the stated goals of the research. The obtained results were compared with the results of the work of Laurence (2005) and Parker (Parker et al., 2017).

In an aim to provide more holistic and better models for risk management, modern scientific methodology is increasingly looking for the complex relationships between variables. In doing so, the estimates of interrelationships and impacts are the most often iterative and stochastic. The complexity of factors that affect the attitude of employees towards risk is emphasized through a survey. The key concept of factor analysis is that multiple observed variables have similar patterns of responses because they are all associated with a latent and not directly measured variable. In order to determine the main factors influencing the risk of human factor, a statistical method of factor analysis was applied to a group of 33 variables. The obtained factors were then used as input variables for binary logistic regression in order to determine the predictive model of the miners' behavior with respect to the rules. IBM SPSS Statistics 25 was used to process the data and the results were presented in MS EXCEL

The research sample consisted of 476 mineworkers from a random selection of open pit mines extracting coal. Information about examinees and their personal attitudes provided data which are considered most relevant for the problem being researched, and are related to the following five variables: gender, age, employment status, education, hierarchy level in the mine and work in shifts are presented in Table 1.

Table 1.
Sample description

Characteristics	Description	Frequency	Percent
Gender	Male	443	93.1
	Female	33	6.9
	Total	476	100.0
Age	20-29	24	5.0
	30-39	126	26.5
	40-49	205	43.1
	50-59	107	22.5
	over 60	14	2.9
Education level	Elementary school	57	12.0
	Qualified worker	207	43.5
	Highly qualified worker	164	34.5
	High school	10	2.1
	Faculty	30	6.3
	Master	5	1.1
	PhD candidate/PhD	3	.6
Service (years)	less than 5	29	6.1
	10-14	50	10.5
	14-24	158	33.2
	25-34	182	38.2
	over 35	57	12.0
The hierarchical position of the employee	Worker in a coal mine	339	71.2
	Administrative worker	38	8.0
	Logistics worker	12	2.5
	Lower-level manager	49	10.3
	Medium-level manager	26	5.5
	High-level manager	12	2.5

3. Results

3.1. Determining the main factors

In aim to determine the main factors that influence people's behavior in terms of risk-taking, the following variables are observed:

- age,
- years of service,

- the description of my job is clear to me,
- I have enough knowledge for my job,
- the nature of my workplace is at increased risk for me,
- the nature of my workplace is at increased risk for others,
- my manager supports me; my manager controls security,
- the manager tells me if I'm doing well,
- I work in a group / team of colleagues,
- when I notice something that may lead to a problem or an accident,
  my reaction depends on my assessment of the danger,
- I feel the support of my colleagues at work,
- I communicate well with my colleagues and there is no problem to understand each other,
- colleagues are generally predictable, competent and well-meaning,
- we all strive to work safely; rules and regulations are important for my safety,
- I know that people violate rules and regulations,
- sometimes it is necessary to break the rules to get the job done,
- executives are aware of violations of rules and regulations,
- being careful will reduce the chance of an accident,
- communication about rules and regulations is generally pretty good,
- managers explain why rules or regulations are necessary,
- improved training and introduction to job will help in understanding and implementing rules and regulations,
- I consider myself effective,
- I have a high degree of self-esteem,
- I'm always focused on work; I'm social,
- I'm ready to work together; I'm an extrovert,
- I feel good in my skin; I am happy,
- I am happy with my overall life,
- I plan to work at the mine for the next 5 years.

In order to determine the main factors that affect risk behavior, an exploratory factor analysis was applied, along with the Extraction Method: Principal Component Analysis.

On checking if the data set is appropriate for the factor analysis: since KMO = 0.841 > 0.6 and the level of significance, Sig= 0.000 < 0.05, the justifiability condition is fulfilled.

Based on the criterions of eigen values, Cattel criterion (scree plot) and the rule of retaining any eigenvalue that accounts for at least 5% of the variance, it was decided to retain four factors for further research. These will approximately explain 48.86% of the variance. These factors are named as:

Satisfaction with life, related to items: I'm ready to work together, I'm always focused on work, I'm an extrovert, I consider myself effective, I feel good in my skin, I'm social, I am happy, I am happy with my overall life, I have a high degree of self-esteem, I plan to work at the mine for the next 5 years, Being careful will reduce the chance of an accident, Rules and regulations are important for my safety, When I notice something that may lead to a problem or an accident, my reaction depends on my assessment of the danger, I have sufficient knowledge for my job, Improved training and introduction to job will help in understanding and implementing rules and regulations.

Supportive leadership style, related to items: My manager controls security, The manager tells me if I'm doing well, My manager supports me, I feel the support of my colleagues at work, Colleagues are generally predictable, competent and well-meaning, I communicate well with my colleagues and there is no problem to understand each other, We all strive to work safely, I work in a group/team of colleagues, Managers explain why rules or regulations are necessary, The description of my job is clear to me.

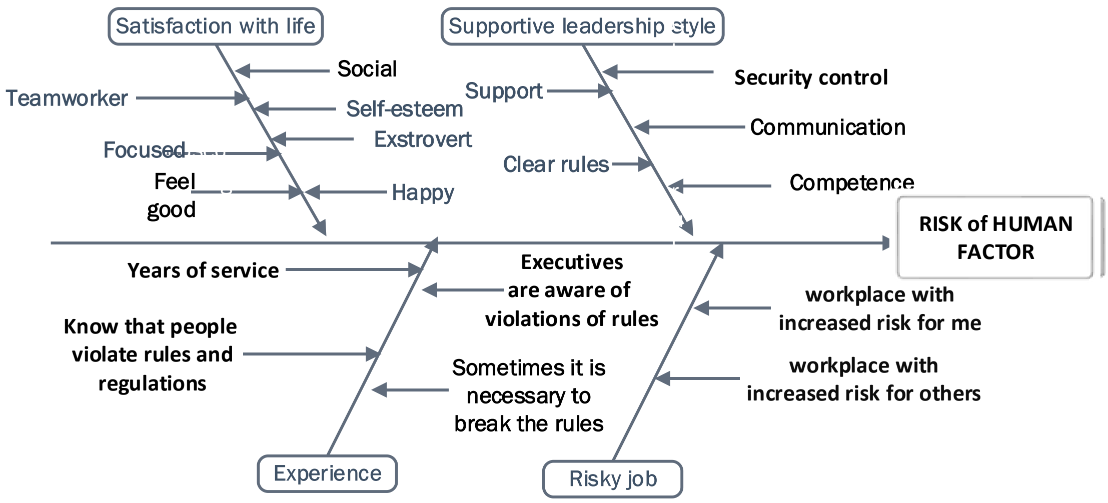

Figure 1. Main human factors.

Experience, related to items: Years of service, Age, I know that people violate rules and regulations, Executives are aware of violations of rules and regulations, Sometimes it is necessary to break the rules to get the job done.

Risky job, related to items: The nature of my workplace is at increased risk for me, The nature of my workplace is at increased risk for others.

3.2. Rules and regulations

The analysis has shown that 109 (22.9%) claimed that they break rules and regulations, whereas 367 (77.1%) claimed that they do not break rules and regulations, Table 2.

Table 2.
Number of examinees according to rule breaking

	Frequency	Percent	Valid %	Cumulative %
I deviate	109	22.90	22.90	22.90
I don't deviate	367	77.10	77.10	100
Total	476	100	100	

Figure 2 shows the answers of the mine-workers about reasons for risk-taking: "the pressure of director", 18%, "simply, people take risk", 17%, "bad rules and regulations" 17%, "it is easiest way to do it", 13%. It is important to note that 22% of all respondents answered "other reasons for risk taking." This means that the list of reasons needs to be improved.

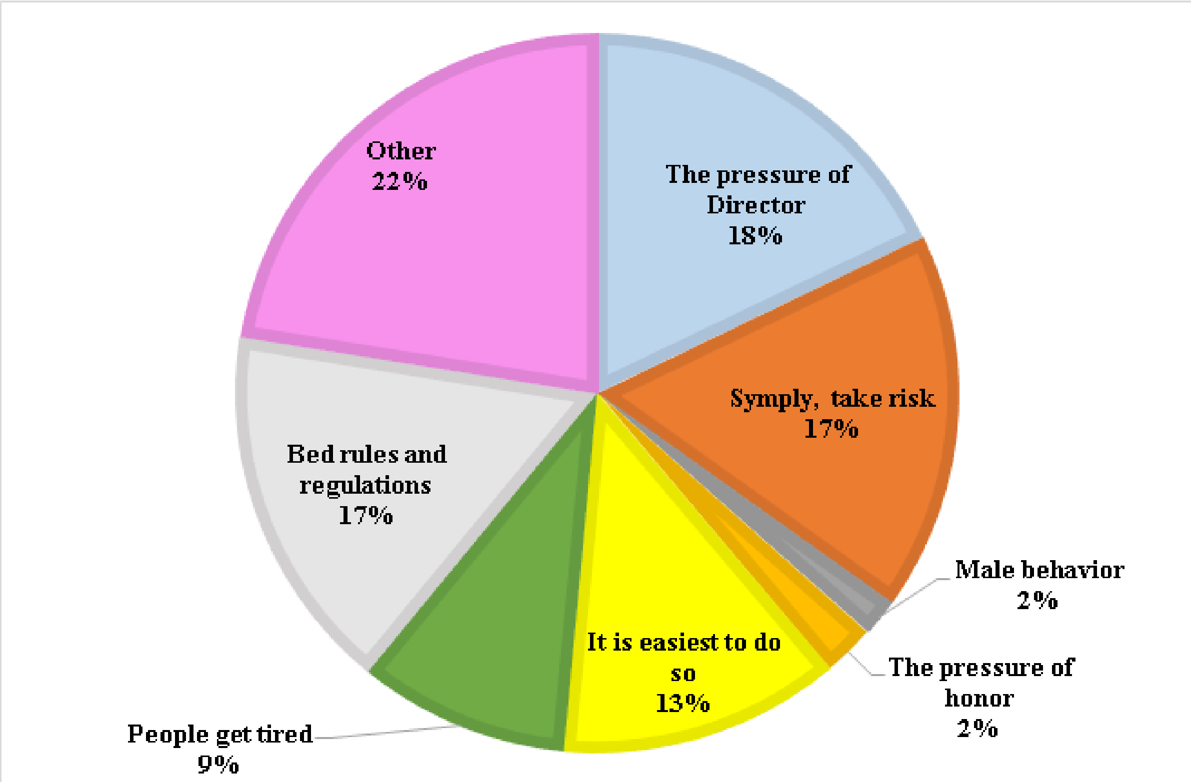

Figure 2. Reasons for risk taking.

In comparison to similar research conducted by Laurence (2005) in several different mines in Australia, the obtained results are different. In his research, the most important reason was "people get tired", 25%, and "it is easiest way to do it", 21%. He had less than 4% "other" answers.

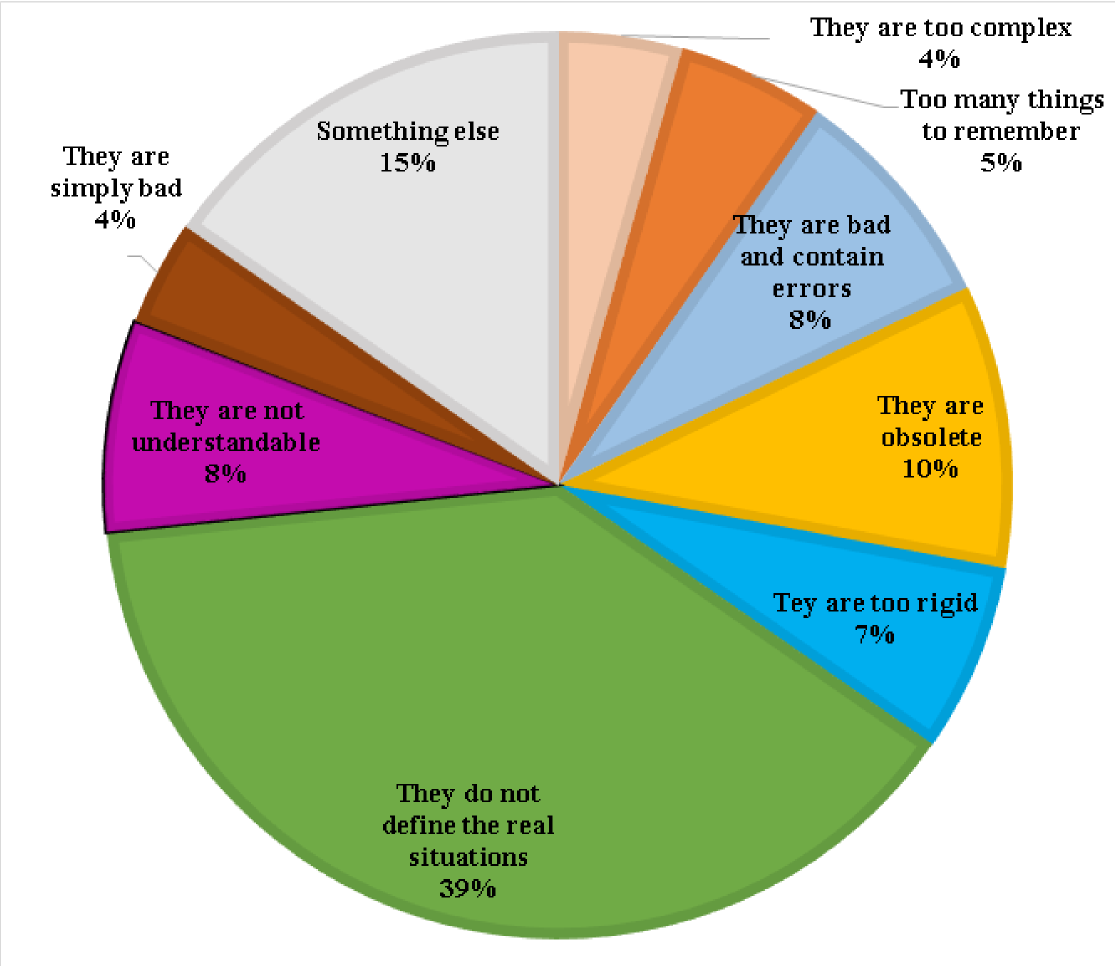

Figure 3. Problems with the rules and regulations.

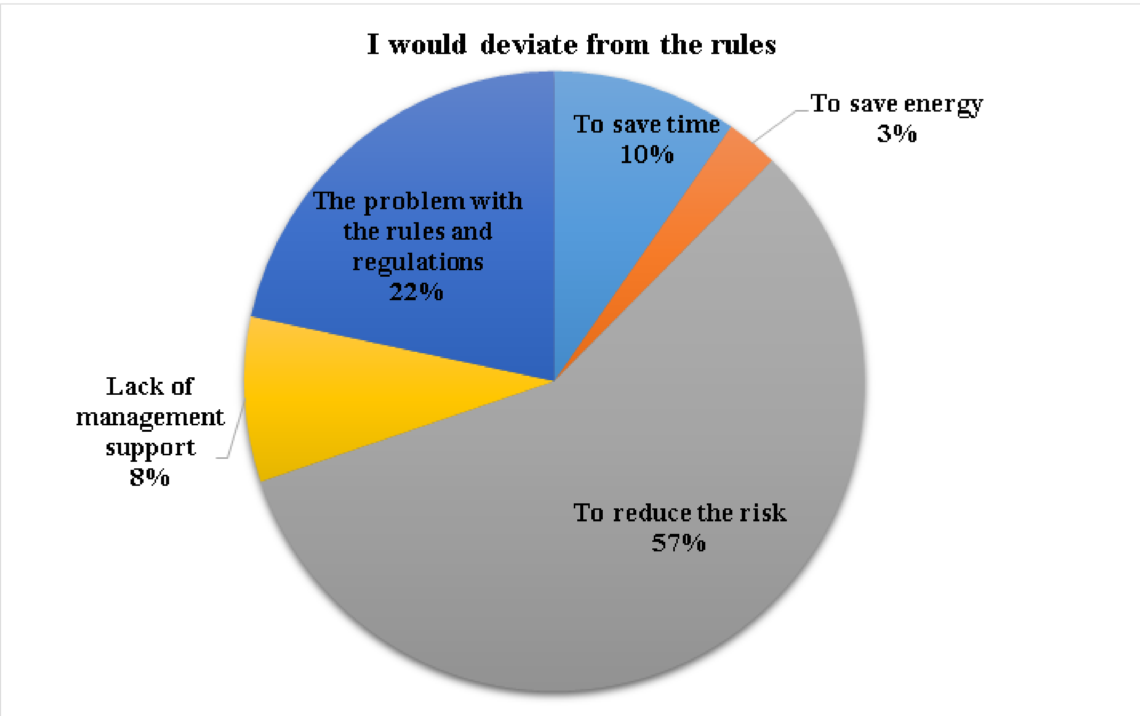

Figure 4. Attitude to the rules.

The results obtained show that 39% of all workers consider that the set rules do not define the real situation on the job; 8% think the rules are not understood, 8% think "rules are bad and contains errors", while 7% of workers think that the rules are too rigid. Results presented by Laurence are different: about 19% of all workers hold that there is a lack of real world in the rules, 18% think "there are too many [rules] to remember", 18% consider the rules too complex, while 16% respondents think the rules are too rigid.

3.3. Prediction model

Situations where **the criterion variable**, i.e. the variable we want to explain or **predict, based on one or more predictor variables,** is **dichotomous or binary,** are relatively common in studies. Binary logistic regression enables the examination of outcome prediction models given in two categories. Examples of binary variable-based categories that are sometimes used as criterion variables are: hired – not hired, follows the rules – does not follow the rules, has learning problems – no learning problems, buys a specific product – does not buy a specific product, leave the country – do not leave the country.

We used the **IBM SPSS Statistics 25** Binary Logistic Regression technique to create the predictive model.

Dependent Variable → Deviation of rules

Predictor Variables: Satisfaction with life; Supportive leadership style; Experience; Risky job

By default, SPSS logistic regression does a list-wise deletion of missing data. This means that if there is missing value for any variable in the model, the entire case will be excluded from the analysis. We have 476 cases, but 467 were used in the analysis.

Table 3.
Case Processing Summary

Unweighted Cases[a]		**N**	**Percent**
Selected Cases	Included in Analysis	467	98.1
	Missing Cases	9	1.9
	Total	476	100.0
Unselected Cases		0	0.0
Total		476	100.0

a. If weight is in effect, see classification table for the total number of cases.

Table 3 lists the block 1logistic binary regression (Block 1: Method = Enter) with predictors included.

The Omnibus Tests of Model Coefficients was applied to ascertain whether the new model (with explanatory variables included) is an improvement over the baseline model (without predictors) Omnibus Tests: -2LL = 80.104 = Model χ^2 $df = 4$, $p < .001$. In this case there is a significant difference between the Log-likelihoods of the baseline model and the new model (sig < 0.001).

Hosmer and Lemeshow (1980) proposed grouping cases together according to the predicted values drawn from the logistic regression model. Specifically, the predicted values are arrayed from lowest to highest, and then separated into several groups of approximately equal size.

Goodness-of-fit (GOF) tests are used in deciding whether the model is correctly specified. They produce a p-value—if this is low (say, below .05), the model is rejected. If it is high, then the model is supported.

Table 4.
Hosmer and Lemeshow goodness of fit test

Step	Chi-square	df	Sig.
1	1.,240	8	0.249

Sig = 0.249 > 0.05. The nonsignificant chi-square is indicative of good fit of data with linear model.

Table 5.
Contingency Table for Hosmer and Lemeshow Test

		Deviation from rules = Not deviate		Deviation from rules = Deviate		
		Observed	Expected	Observed	Expected	Total
Step 1	1	44	45.660	3	1.340	47
	2	44	44.344	3	2.656	47
	3	42	42.538	5	4.462	47
	4	41	40.936	6	6.064	47
	5	40	39.145	7	7.855	47
	6	37	37.456	10	9.544	47
	7	36	35.347	11	11.653	47
	8	40	32.248	7	14.752	47
	9	24	27.739	23	19.261	47
	10	14	16.587	30	27.413	44

For each of ten groups the observed number of deviate and non-deviate events was calculated, as well as the expected number of deviate and non-deviate events. The expected number of deviate events is just the sum of the predicted probabilities over the individuals in the group. For each bin and each event, we have a number of observed cases and an expected number predicted from the model.

The Classification table shows the stacking of the empirically obtained (Observed) categorical affiliation of observation units on criterion variables and their predicted (Predicted) categorical affiliation based on a logistic model containing all the predictors introduced in block 1. This table is the equivalent to that in Block 0, but is now based on a model that includes our explanatory variables.

Table 6.
Classification table[a]

Observed			Predicted		
			Deviation from rules		Percentage Correct
			Not deviate	Deviate	
Step 1	Deviation from rules	Not deviate	352	10	97.2
		Deviate	77	28	26.7
	Overall Percentage				81.4

a. The cut value is .500

As can be seen, our model now correctly classifies the outcome for 81.4% of all cases. The model variables are presented in Table 7.

Table 7.
Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	Satisfaction with life	-0.612	0.118	27.054	1	0.000	0.542	0.430	0.683
	Leadership	-0.292	0.118	6.071	1	0.014	0.747	0.592	0.942
	Experience	0.506	0.135	14.116	1	0.000	1.658	1.274	2.159
	Risky job	0.797	0.134	35.280	1	0.000	2.219	1.706	2.886
	Constant	-1.547	0.140	121.767	1	0.000	0.213		

The table contains the logistic coefficients estimates for the model with the predictors introduced in block 1 (column B). In this case, there is a coefficient b0 in the Constant row, S.E. The asymptotic standard errors for the individual logistic coefficients are shown.

The Wald column contains Wald 's H^2 statistics, the df degree of freedom column, and the Sig column (to test the hypothesis that the logistic coefficient for the predictor variable is zero).

Column exp (b) contains exponential logistic coefficients that are very important for interpreting logistic regression outcomes. These are the values for the logistic regression equation for predicting the dependent variable from the independent variable. The logistic model estimated from a given sample is shown by formula (1).

$$\ln(ODDS) = \ln\left(\frac{\hat{Y}}{1-\hat{Y}}\right) = \ln\left(\frac{P(deviate)}{1-p(deviate)}\right) = -1.547 - 0.612 * Satisfaction\ with\ life - 0.292 * Leadership\ style + 0.506 * Expirience + 0.797 * Risky\ job \quad (1)$$

If we expose the logistic coefficient for “Satisfaction with life”, we obtain the value -0.612 in the “B column” and the column Exp (b) of the Variables in the Equation table. Here:

exp (b1) = exp (-0.612) = 0.542 is a odds ratio (2 no deviate responses for every 1 “deviate from rules”, p = 0.33),

Thus, the chances of answering the question with “deviate from rules” (according to non deviated) are twice-times decreased when the "value" on the “Satisfaction with life” predictor variable is "increased" by 1 and the other three predictors in the model are kept constant.

Likewise, if we expose the logistic coefficient for “Risky Job”, we obtain the value in the row “Risky Job” and the column Exp (b) of the Variables in the Equation table: exp (b4) = exp(0.797) = 2.219.

This actually means that the chances for the answer “deviated from rules” is 2.219 times higher for the “Risky job” predictor.

4. Discussion

According to ISO 31000, effective risk management should be an integral part of all organizational processes and should take into account human and cultural factors, (Purdy, 2010). In our work, a survey was conducted to identify the major human risk factors. These then served as predictors for workers' behavior with respect to adherence to rules and procedures.

The obtained results indicate that leadership plays an important role in worker behavior. A supportive leadership style results in more responsible employee behavior and a lower probability of deviation from rules and procedures. Leadership is a category that can be managed. The results also indicate that worker pro-safety attitudes are strongly influenced by the difficult to control factor of "life satisfaction". However, our research indicates that riskier work and longer work experience increase the likelihood of rule breaking.

According to the results of the empirical research, satisfaction with life, supportive leadership style, experience and risky job are the main factors that influence people's behavior in terms of risk-taking. Life satisfaction in the context of risk reduction is a category that is difficult to objectively assess and therefore measure. Helbo Jesperson et al. (2016) “investigated how two Danish municipalities have transformed the general audit guidelines into internal audit practices capable of targeting the psychosocial risks”. They found it is “difficult to assess psychosocial risks”, “because the psychosocial risks appear less directly visible” and “because managing these types of risks is more complicated”.

Due to its complexity, interconnectedness with other areas of the human life and the reflection it gives on work performance, life satisfaction is a topic of modern research related to risk. Siebert et al. (2020) noted that “goal-directed behavior driven by effective decision making is a meaningful determinant of life satisfaction”. With this notion in mind, by the end of 2016, standard ISO 45001 was developed to supplement OHSAS 18001, “with regard to managing and auditing psychosocial risks” (Helbo Jesperson et al., 2016). ISO 45001 fosters the development of “a culture of prevention” (AFNOR, 2018). The results of ESENER 2 showed that psychosocial factors are a huge challenge for risk management in Europe (EU-OSHA, 2015). Here, employee participation (either informal or formal) appears to be important in diminishing psychosocial risk.

Our research revealed that the main reasons for risk-taking are “the pressure of the director”, “simply, people take risk”, “bad rules and regulation”, “it is easiest way to do it”, and other reasons which needs to be explored more deeply. The obtained results are comparable to results from a similar survey of Australian mine-workers by Laurence (2005). Here, accordingly, the reasons for risk-taking are “people get tired” and “it is easiest way to do it” (at 21%). In his conclusions, he underlined the relationship between safety culture and “greater awareness, understanding, and compliance with rules and regulations”.

The results our work generated show that leadership support is an important safety factor. This is also in line with the research of Parker et al. (2017), who indicated that the support and commitment of management, as well as the maintenance of open communication channels are extremely important for ensuring security. Indeed, Weissbrodt, and Giauque (2017) suggest “the possibility of positive outcomes of inspectors’ interventions on psychosocial risks in supportive contexts and with appropriate training and resources”.

In this paper, we set out to gain understanding of the views of mine-workers on rules and procedures. The obtained results show that 39% of all pit employees consider that rules are not adequate and do not define the real situation on the job; 8% think the rules are not understood, 8% believe that “rules are bad and contain errors“, while 7% of all workers think that the rules are too rigid. Laurence (2005) notice similar views. Accordingly, the main problems with the rules and procedures were as follows: lack of real world reality, too many to remember, complexity, rules too rigid. He suggested that more efficient rules by themselves are not a sufficient response to achieve a safe working environment. Laurence underlined the importance of a thriving safety culture and holds that open and working communication channels are crucial in enabling mine site safety. Weissbrodt, and Giauque (2017) reinforce this notion, as in their work they saw that security is enhanced by a mine-site employing an experienced and stable workforce. Our research supports the findings of both Laurence and Weissbrodt and Giauque.

Problems of compliance with rules and regulations and the issue of their quality have been recognized as a topic worthy of research by researchers. To better deal with uncertainties regarding beliefs and values, policymakers should strive for robust rules which “need to be adaptive and flexible so that they are easy to revise as new information becomes available" (Hallegatte, 2015).

5. Summary

Regulatory requirements for workplace safety represent factors that force companies to devote considerable attention to considering the human factor in risk management and improvement of safety at work. The reduction of risks related to the human factor represents the most important step in risk reduction in industrial systems

The introduction of rules and procedures raises the level of security in high-risk systems, but risk management should be a "live" process that must not be rigid, but rather be open to innovation in the formation of more effective, efficient and clearer policies and procedures, with the aim of increasing safety.

The obtained results indicate the need for continuous improvement in the risk management process and in set rules and procedures, by involving workers and applying feedback from them.

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